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Report to the Test Director

TIMING AND FIRING

Operation Tumbler-Snapper

by

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and Staff

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ABSTRACT

Edgerton, Germeshausen & Grier, Inc. (EG&G) was commissioned to do the following tasks as part of the timing and firing functions on Tumbler-Snapper (April to June 1952).

1. Generate and distribute predetonation timing signals for all shots—four airdrops and four tower shots.
2. Install and operate switching relays connected to the timing circuits at the various experimental locations.
3. Install and operate the bomb-firing and monitoring circuits for nonairdrops.
4. Determine the time of detonation with respect to world time.
5. Determine, for airdrops, the time of fall.
6. Generate and deliver to the Communications Group a 1000-cycle tone keyed to a specified code.
7. Telemeter, record, and indicate meteorological data.
8. Provide photocell-actuated Blue Box fiducial markers for various experimenters to give millisecond accuracy to zero time signals.
9. Provide timing dry runs for the benefit of experimenters twice daily and more often if required.
10. Provide personnel to serve as members of the Firing Team as directed by the Test Director.

Five major stations were operated (one Control Point and four switching stations), and upward of 500 separate signals were operated at about 200 separate locations.

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ILLUSTRATIONS

TABLES

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TIMING AND FIRING

1 TIMING SYSTEM

The timing and firing system for Tumbler-Snapper operated in the same general manner as on Operation Buster-Jangle.[1] This system was developed and proved on Sandstone,[2] Ranger,[3] and Greenhouse.[4] The Control Station was simply rewired with an increase in capacity; two completely new timer stations were built and equipped, one at Frenchman Flat and one in Yucca Basin; and a third new timer station replaced the old split-room Buster station 210.

2 TIMING GROUP OPERATIONS

2.1 Installation and Dry Runs

The timing group is charged with providing accurate timing signals to all experimenters associated with a test detonation.[5] The signals are supplied in the form of relay closures at the site of the experiment. The relay at a site is furnished, installed, and wired into the timing system by personnel of the timing group. The experimenter has for his use four double-throw circuits on the timing relay. Also available is a Blue Box, for installation at the experiment site, that triggers on gross light from the detonation. This unit delivers a voltage pulse immediately after zero, followed by a relay closure within 2 msec.

For test purposes in the field, the timing group schedules a dry run every morning with zero time at 10 o'clock and every afternoon with zero time at 3 o'clock. No experiment is connected into the dry run without a specific request from the experimenter. An experimenter can request that his signals be included in any particular runs or in all runs.

2.2 Typical Timing Signals

Tables 1 and 2 give the typical timing signals for air and tower shots. The utility and choice of these signals is thoroughly discussed in the references.

2.3 Meteorological Measurements

One of the most important pieces of information necessary to the measurement of yield by fireball photography is the density of the surrounding atmosphere. For airdrops an estimate of atmospheric conditions must be relied upon, but for tower or ground shots, where the point of detonation is known and easily accessible, continuous measurements at locations up to zero time are advantageous.

Another pertinent piece of information for radiological reasons is a continuous and immediately available history of wind velocity and direction. Such information is of increasing importance to the Test Director, who must make a last-minute decision on local wind conditions for the purpose of evaluating danger to troops who may be participating in the operation for training purposes.

For these reasons EG&G undertook, immediately prior to Tumbler-Snapper, to make the

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Table 1 — TIMING SIGNALS FOR AN AIRDROP

Time	Error with respect to predicted zero, sec
Manual Signals	
−15 min	*
−5 min	*
Automatic Signals	
−30 sec	±0.05
−15 sec	±0.05
−5 sec	±0.05
−2.5 sec	±0.05
−1.5 sec	±0.05
−0.5 sec	±0.05
Zero†	±0.05
+3 sec‡	±0.05

*The first two (manual) signals for an airdrop occur in relation to predicted time of release. The experimenter must consider that the time of release may be delayed after a manual signal has been sent out.

†This signal is for dry runs only.

‡This signal cuts off all relays.

Table 2 — TIMING SIGNALS FOR A TOWER SHOT

Time	Error with respect to actual zero, sec
Manual Signals	
−60 min	±0.5
−30 min	±0.5
Automatic Signals	
−15 min	±0.1
−5 min	±0.1
−1 min	±0.1
−30 sec	±0.05
−15 sec	±0.05
−5 sec	±0.05
−1 sec	±0.05
Zero*	±0.05
+1 sec†	±0.05

*This signal is for dry runs only.

†This signal cuts off all relays.

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following meteorological measurements on the tower shots:

1. Wind velocity at a point within 2 miles of zero to be telemetered and recorded at the Control Station up to and through zero time, if possible.
2. Wind direction at a point within 2 miles of zero to be telemetered and recorded at the Control Station up to and through zero time, if possible.
3. Dry-bulb temperature at zero point to be telemetered to the Control Point and recorded up to zero time.
4. Wet-bulb temperature at zero point to be telemetered to the Control Point and recorded up to zero time.
5. Barometric pressure at zero point to be telemetered to the Control Point and recorded up to zero time.
6. Barometric pressure, temperature, and relative humidity to be recorded at several timing stations in the area but not telemetered.
7. Local wind velocity, direction, barometric pressure, temperature, and relative humidity to be indicated at the Control Point for the convenience of the Test Director and staff.

This project was started quite late, but, with the cooperation of the Air Weather Service and the Bristol Company, enough equipment was obtained before the first tower shot to meet all commitments except the requirement for telemetered barometric pressure. It is expected that all equipment will be available for Operation Upshot. Results are shown in Table 5.

3 TUMBLER-SNAPPER EQUIPMENT

The Control Station equipment consisted of a power rack, recorder rack, timer rack, test rack, signal-distribution racks 1 and 2, world-time rack, and a relay and tone-signal rack (Fig. 1).

The Frenchman Flat timer station 370 had a power rack, relay rack, and three signal-distribution racks.

Each of the three timer stations in Yucca Basin had a power rack, relay rack, and three signal-distribution racks.

Four tower stations were equipped with zero racks.

More than 300 DN-11 relays were used to service the shot at Frenchman Flat, the three shots in Area 7, and the four tower shots, for a total of about 500 signals.

During Operation Buster-Jangle, a need was felt for battery-operated Blue Boxes with millisecond accuracy to be used when a-c power was unavailable. Thirty of these boxes were built for Tumbler-Snapper, similar to the Type A Blue Box except in the type of power supply. These operated successfully except for some battery failures and a run of poorly constructed 929 photocells. One hundred boxes of a revised design were made for Operation Ivy.

4 RESULTS

No serious difficulty was experienced with the basic timing and firing system.

The times of detonation with respect to world time are given in Table 3, and the clock photographs are reproduced in Fig. 2.

The times of fall for Tumbler airdrops are summarized in Table 4.

The Snapper meteorological measurements are listed in Table 5.

REFERENCES

1. Buster-Jangle Report, "Timing and Firing," WT-403.
2. Sandstone Report, Annex 3, Part I, Vol. 15.
3. Report EG&G 1057, "Timing on Operation Ranger."
4. Greenhouse Report, Annex 1.11, "Timing and Firing and Fiducial Markers," WT-99.
5. Tumbler-Snapper Instrumentation Chart.

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Table 3 — TUMBLER-SNAPPER WORLD TIMES, PACIFIC STANDARD TIME SHOWN

	Shot 1, Apr 1, 1952, 0900	Shot 2, Apr. 15, 1952, 0830	Shot 3, Apr. 22, 1952, 0930	Shot 4, May 1, 1952, 0830	Shot 5, May 7, 1952, 0415	Shot 6, May 25, 1952, 0400	Shot 7, June 1, 1952, 0355	Shot 8, June 5, 1952 0355
Slow Clock Readings								
At shot time	0900 : 11.2	0829 : 57	0930 : 10.5	0829 : 58.0	0414 : 59.7	0400 : 01.3	0355 : 00.6	0355 : 00.8
At calibration	0915 : 03.1	0905 : 00	0945 : 00.2	0844 : 59.5	0425 : 00.5	0415 : 01.8	0415 : 01.0	0405 : 00.6
WWV signal	0915 : 00.0	0905 : 00.0	0945 : 00.0	0845 : 00.0	0425 : 00.0	0415 : 00.0	0415 : 00.0	0405 : 00.0
∴ correction	− : 03.1	: 00.0	− : 00.2	+ : 00.5	− : 00.5	− : 01.8	− : 01.0	− : 00.6
Shot "time"	0900 : 08.1*	0929 : 57	0930 : 10.3	0829 : 58.5	0414 : 59.2	0359 : 59.5	0354 : 59.6	0355 : 00.2
Fast Clock Readings								
At shot time		0.945 min	0.175 min	0.975 min	0.9915 min	0.9905 min	5.000 min	5.0045 min
At calibration		4.9942†	5.008‡	4.990§	0.004¶	4.9965**	5.003	4.999
WWV ref		5.000	5.000	5.000	0.000	5.000	5.000	5.000
∴ correction		+0.0058	−0.008	+0.010	−0.004	+0.0035	−0.003	+0.001
Shot + corr		0.9508 min	0.167 min	0.985 min	0.9875 min	0.9940 min	0.997 min	0.0055 min
× 60 (sec)		= : 57.05	= : 10.02	− : 59.1	= : 59.25	= : 59.6	= : 59.8	= : 00.3
World Time Corrected								
	0900 : 07.5	0926 : 57.05	0930 : 10.02	0829 : 59.1	0414 : 59.25	0359 : 59.6	0354 : 59.8	0355 : 00.3

*Frequency shift in power supply after zero requires a correction of − 0.6 sec in addition to calibration and nullifies all fast clock readings on Shot 1.
†Weighted average of calibrations at 0905 and 0940
‡Weighted average of calibrations at 0905 and 0945.
§Weighted average of calibrations at 0815 and 0840.
¶Weighted average of calibrations at 0345 and 0425.
**Weighted average of calibrations at 0325 and 0415.

Table 4 - TIMES OF FALL FOR TUMBLER AIRDROPS

Shot	Time of fall, sec			
	Clock 1	Clock 2	Strike aircraft	
1	34.78	34.78		
2	34.52	34.52	34.53	34.55
3	42.28	42.28	42.28	42.32
4	36.41	36.41		

Table 5 — SNAPPER METEOROLOGICAL MEASUREMENTS

Shot	Air temperature, °C	Barometric pressure,* mb	Relative humidity, %
5	16.6	858	37
6	15.4	858	41
7	13.2	865	48.1
8	20.6	856.5	50.4

*These readings extrapolated to the tower from the Air Weather Service information and close-in EG&G instrumentation. See Sec. 2.3.

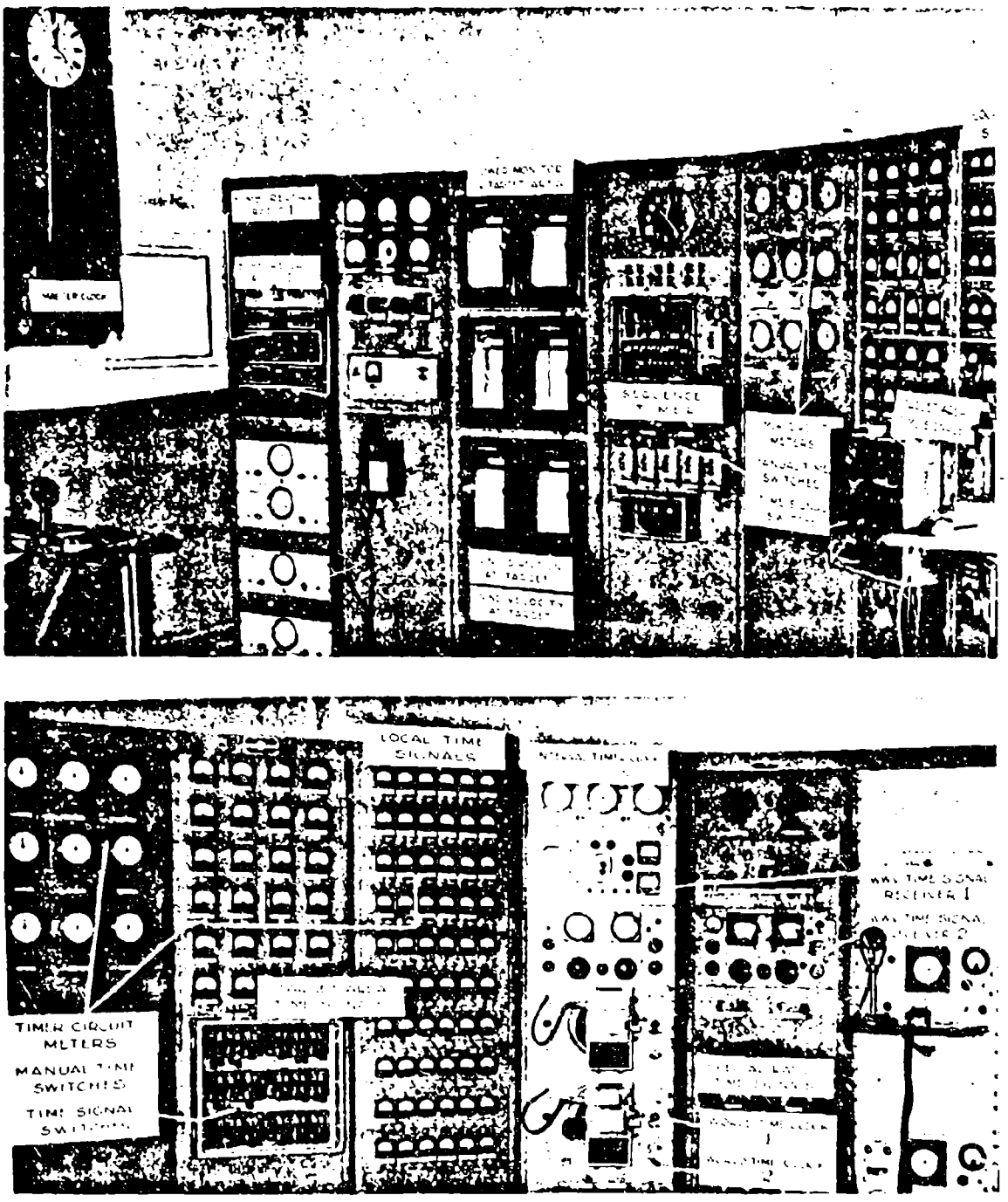

Fig. 1—Display photographs of control room.

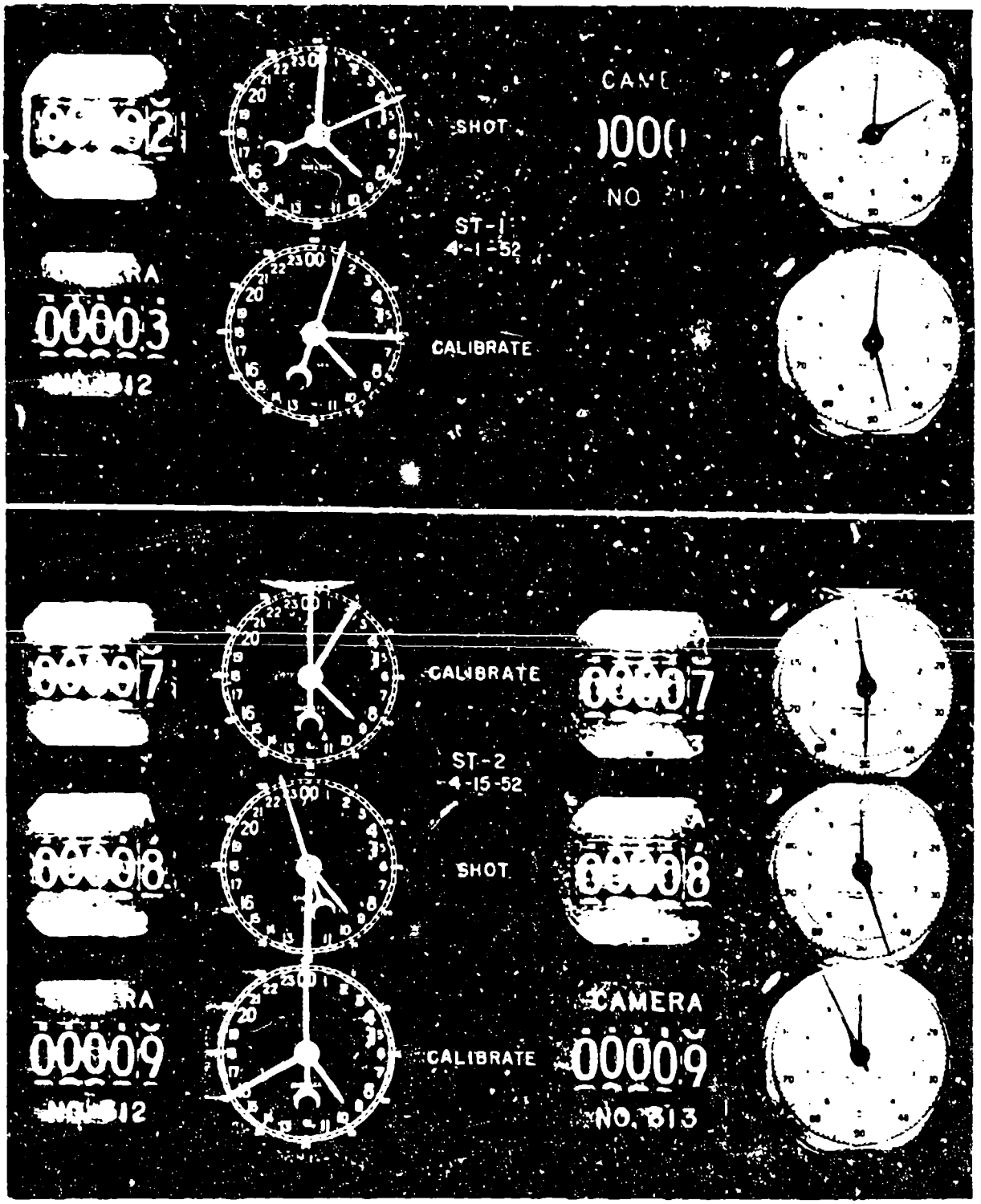

Fig. 2a — Tumbler-Snapper world time readings.

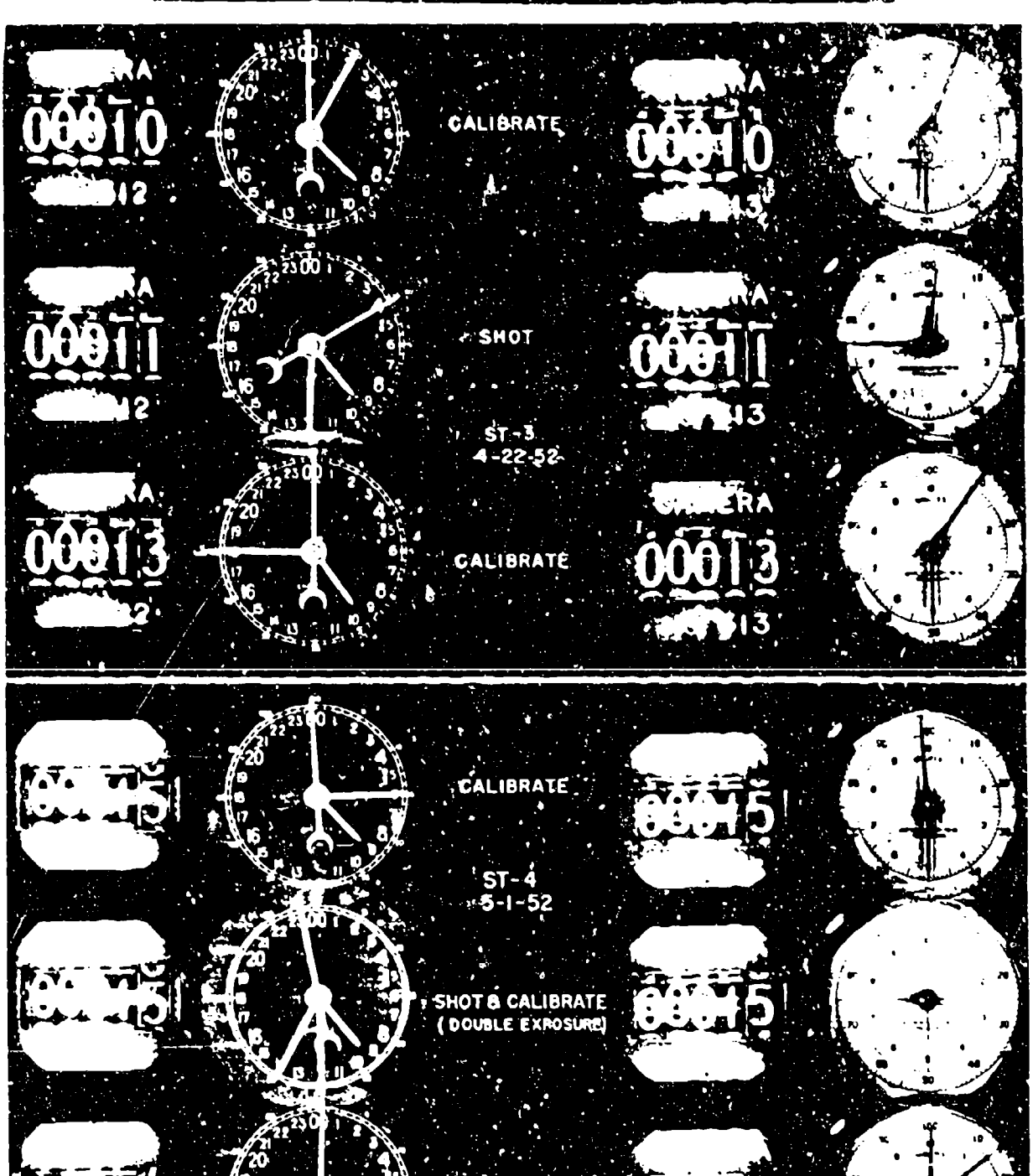

Fig. 25—Tumbler-Snapper world time readings.

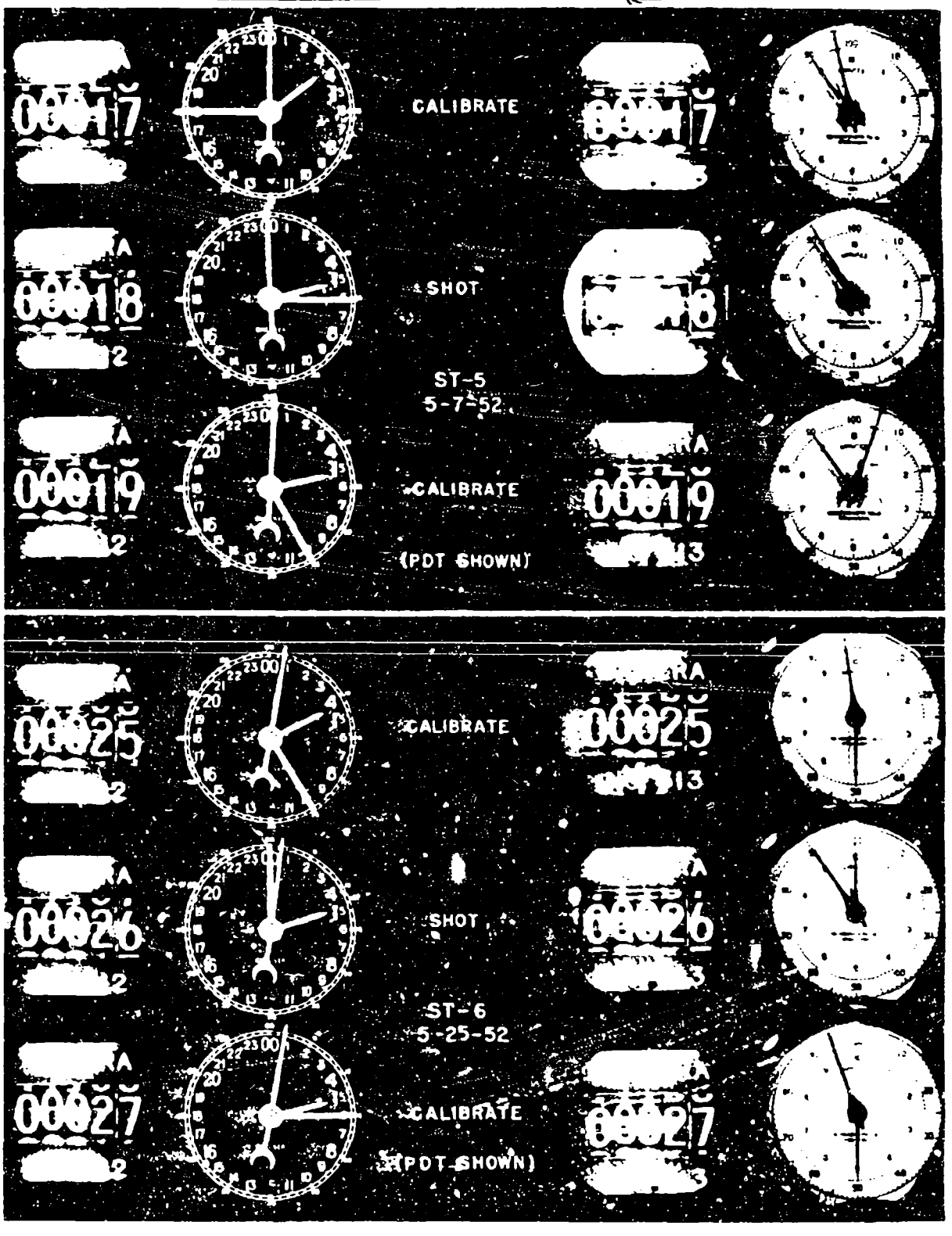

Fig. 2c — Tumbler-Snapper world time readings.

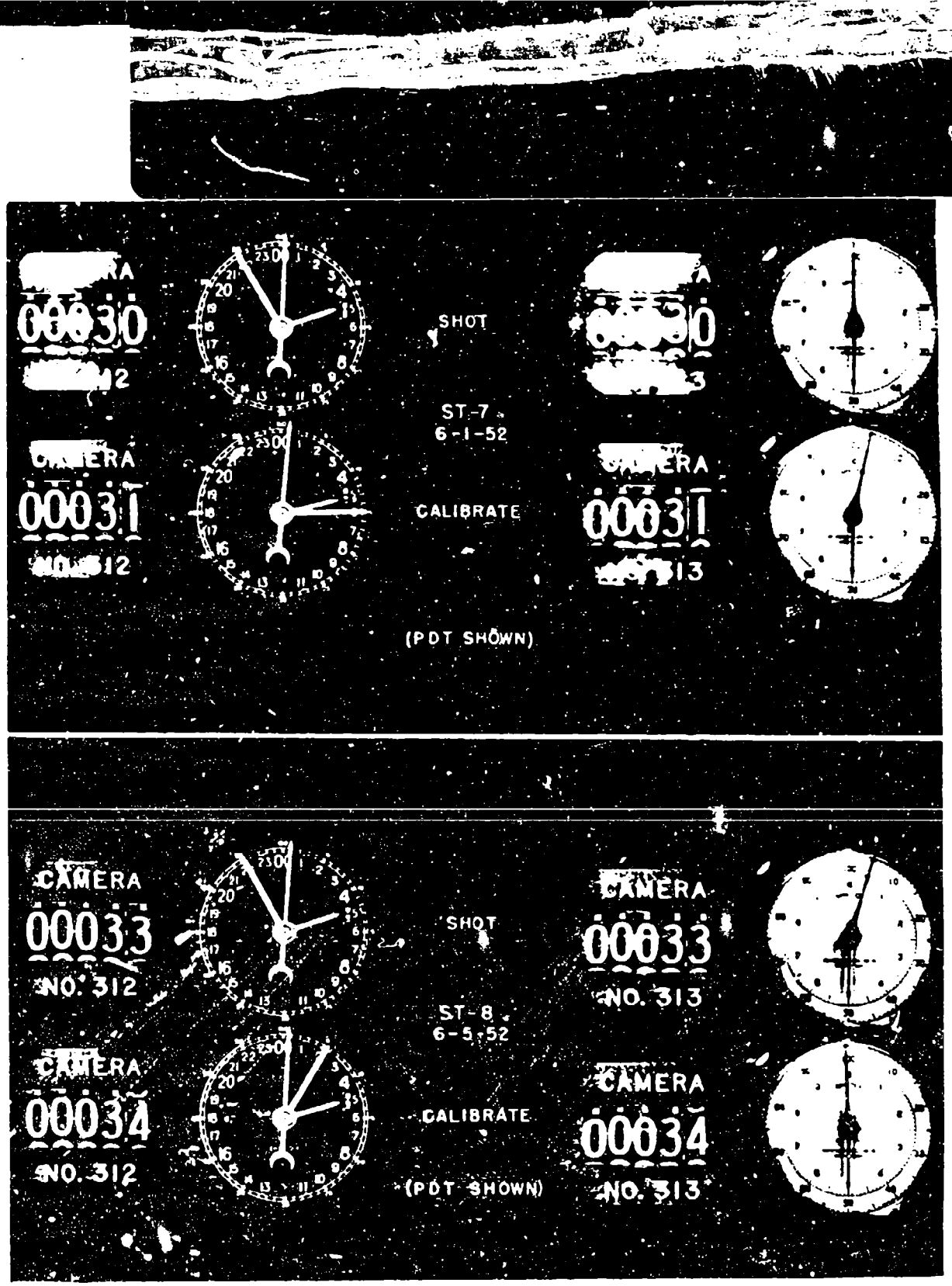

Fig. 2d—Tumbler-Snapper world time readings.